MIE346 – Design Assignment 4 (4%)

Due Dates: See deliverable steps.

In the past three design assignments, you have created multiple realistic circuit designs using hand calculations and software tools (PSPICE) to solve practical, real-world problems. In the PRA sessions you have learned to build prototype circuits for testing, measurement, and verification purposes using tools like the solderless breadboard. Within the mechatronics design process, however, these tools and techniques only allow us to complete conceptual design and parts of a detailed, final design. Finished, permanent, ready-to-manufacture designs still need to be realized. A crucial step in producing a finished product is moving from prototype-friendly methods of circuit building to more permanent solutions.

Manufactured circuits are typically built on **printed circuit boards (PCBs)**, where components are **soldered** onto fixed **traces** of copper. These PCBs can be designed to conform to specific shapes, and the designer is also responsible for determining the layout of the components as well as their interconnection. PCB design is a complex skillset that will take years of industry practice to master. For this reason, we hope to introduce it to you now, early on in your career, so that you may gain more practical experience. It is also important to note that a complete PCB design also interacts with the mechanical structure of the product being designed – one must take into account the size and location of components, the location of external connectors, controls, and wires, mounting patterns, and so on.

In short, as a circuit-building method that can be used in a finished product, the design complexity and the cost of iteration on a failed design is high. Thus, if you plan to do any significant amount of mechatronics design in your future career, it is crucial that you learn how to create PCBs that work within your design constraints with minimal chance of error. To reduce complexity in this assignment, we will develop only a basic process which you can build on in later courses and assignments, particularly in capstone (if your project requires PCB fabrication). We will also be standardizing the **physical parts** you receive to one of three pre-selected options. Even with these simplifications, though, you will learn a method that can be used to create ready-to-use boards for other designs.

Design Assignment Process

NOTE: The following process has **multiple** deadlines, as you will be receiving an actual, physical PCB, 3-D printed case, and kit of parts **to keep**. The earlier deadline is set so that we can prepare the correct number and type of manufactured boards.

General Note: As a more production-focused assignment, the focus of all grading will be on the technical accuracy and the final product (CAD, schematic, printer files, PCB files) at each step. Please **do not** include extensive written explanations or reports, as this is not the focus.

DEADLINE: Thursday, March 30 (11:59pm)

In this step, you will tell us which prior design assignment your case and PCB will be based on (color organ, power supply, or motor driver).

1. Review your past designs for Design Assignment 1, 2, and 3. You will be selecting **one** of these designs to turn into a finished **PCB Layout** (ready to manufacture) **and** a **case or housing design**

for the finished product. At the end of the assignment you will have (i) a design of your own that could be built by a PCB fabrication studio, (ii) a known, working, **physical PCB** designed by us of the same type (i.e., if you select DA2, we provide a power supply board), and (iii) a 3-D printed copy of the case/housing that **you** design. You will be able to keep the PCB and the 3-D printed parts. To this end, you may want to be strategic about your choice. Some things to consider (you do not need to answer these questions in a report, only think about them):

   a. How close was the prior design to functioning? Were there real-world components missing? For instance, does your design have power supply connections shown? Input and output connections? Were realistic parts selected? Realistic voltages, currents, etc.?
   b. Do I want to build the design? If so, note that you have been able to keep parts from the labs, so modifying your design to overlap with the available parts might be beneficial. In a similar vein, the known, working PCBs we will provide are designed to overlap with these parts kits as much as possible, so that you may easily build the circuit if you desire.

2. **[0.25%] Select a prior design assignment and indicate your preference on Blackboard** by following the instructions in the post "Design Assignment 4 – Part 1." All that is needed is to indicate your preference of PCB type, so the actual work for this step needed is very minimal. It is also **crucial** that you meet this deadline, otherwise you will not receive a physical PCB.

DEADLINE: Thursday, April 6 (11:59pm)

In this step, you will design a case for a known PCB layout/footprint. We will provide a physical print of the case you design to you. Your later PCB design must then fit within this same case.

3. Revisit your prior design and add any components which were missing from the earlier design, particularly those needed for real-world construction. This would include connections for power, input, output, and any other important parts (fuses in the power supply, LEDs in place of the 'light' in DA1, power indicator LEDs, etc.). You may also wish to modify your design to fix prior errors or improve its expected performance based on new course content, but keep in mind that this is not the focus – try to make minimal changes, as most of your effort should go towards the case design and board layout.
4. **[1.25%]** Using the CAD software of your choice (Solidworks is available on the ECF computers, and Onshape can be freely used at home), **create a design for a case to house your future circuit board design**. You should consider:
   a. How the case will be assembled
   b. How the board will be mounted
   c. How the parts on the board will fit within the case
   d. The opening needed for parts that connect to the outside (power, input, and output connectors, LEDs, potentiometers, etc.).

   We will be posting the layout/footprint and critical dimensions of the physical PCBs that you will have at the end of the project. The case you design should be created to accommodate these boards. The board should be able to fit and mount properly (allow for screw holes) in the case, and the case should close around and protect the board, while providing openings for anything that needs to be externally accessible (power/input/output connectors, potentiometers, or LEDs). You **may** add extra features to the case to support your unique circuit design (which might contain parts that ours does not). However, the grading will be focused on if your case properly suits the PCB design we have given.

Before the deadline, **submit your completed design** at the link "Design Assignment 4 – Part 2" on Blackboard. **Be sure to read and follow the submission instructions attached to that post carefully**. These instructions include steps where you process ('slice') your model using the 3-D printer's software. If you do not submit, **you will not receive your printed design**, as due to the volume of printing that must be completed there is no time to request a revised design from you in the case of an issue. In short, incomplete or incorrect designs will be omitted from printing.

DEADLINE: Thursday, April 13 (11:59pm)

You will now design a PCB, based on your prior design assignment circuit, which fits within the case from the prior section. Although we cannot manufacture your unique PCB design, we will provide you with a known, working physical PCB that matches the footprint provided earlier.

5. **[0.5%]** Using the posted guide to EagleCAD and your revised circuit, create a schematic capture for your circuit in the schematic capture part of the software. Be sure to include external connectors for input, output, and power – you can select any type that you think is suitable. However, note that your final circuit and PCB **must** fit within the case you designed in the prior step. Include the schematic in your report as **Figure 1**. Add a **minimal** explanation of any changes you have made to your design.
6. **[2.0%]** Convert the schematic into a PCB layout, again using the posted guide. Keep in mind that the board must fit within the case you designed in the earlier steps. If you detect a problem in the prior design that you have already submitted, you may still change the design to allow this step to proceed. You would **not** resubmit the prior step in this case, however. Include **two** images of the completed layout, **top and bottom**, as **Figure 2** and **Figure 3** in your report. These images should be large (half page or more) to allow traces to be easily seen. Submit your **completed report with figures and PCB output files (Eagle and Gerber files)** using the final link under "Design Assignment 4 – Part 3" on Blackboard. As with prior steps, be sure to **read and follow the submission instructions** listed under the post. These instructions include steps to produce **Gerber files**, which are the actual files that one would submit to a PCB fabrication service.
7. We will set up times for you to collect your unique 3-D printed case, chosen PCB, and remaining components. These are not strictly needed to complete the graded part of the assignment, but it is our intention that you can and would use them to actually build one of these designs. We will be posting additional information about how to access other building resources, such as the soldering stations, as well.

Your unique PCB design is now ready to be sent for manufacturing. While there are many nuances to the proper design and layout of PCBs, the above process can be used to create boards for small projects; the final step generates output files in the format accepted by most low-cost, small-run, online PCB fabrication services. If you are interested in actually producing your own designs, you can also repeat the steps of this assignment with a different circuit. If you are considering creating your own PCBs for some projects, please let us know – we would be happy to help!